Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on Changes in the Environment and Fish Populations

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2016

Canadian Technical Report of
Fisheries and Aquatic Sciences 3174

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Canadian Technical Report of Fisheries and Aquatic Sciences

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TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK) AT SHINGLE POINT, YT: OBSERVATIONS ON CHANGES IN THE ENVIRONMENT AND FISH POPULATIONS

by

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Cat. No. Fs 97-6/3174E-PDF ISBN 978-0-660-05736-1 ISSN 1488-5379

Correct citation for this publication is:

Brewster, J. D., Neumann, D., Ostertag, S. K., and Loseto, L. L. 2016. Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on Changes in the Environment and Fish Populations. Can. Tech. Rep. Fish. Aquat. Sci. 3174: v + 23 p.

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ABSTRACT

Brewster, J. D., Neumann, D., Ostertag, S. K., and Loseto, L. L. 2016. Traditional Ecological Knowledge (TEK) at Shingle Point, YT: Observations on Changes in the Environment and Fish Populations. Can. Tech. Rep. Fish. Aquat. Sci. 3174: v + 23 p.

Understanding the environmental changes and determining baseline information for Beaufort Sea fishes is a crucial step in sustaining the fish populations and habitats within a changing Arctic climate. Shingle Point, YT is a traditional and modern day fishing and hunting community for Western Arctic indigenous people and is part of a marine protected area and the Inuvialuit Settlement Region (ISR). The incorporation of Traditional Ecological Knowledge (TEK) is important in understanding the changes in this coastal habitat. During the summer of 2015, Shingle Point harvesters and their families participated in TEK interviews. The interviews provided observational information on: 1) fish population changes, 2) environmental changes, 3) concerns, and 4) reasons to return to Shingle Point. Results from the TEK interviews indicate changes have been observed in the environment and coastal fish populations for decades. The utilization of TEK in the form of specific and open-ended interviews/questionnaires can be used to document and understand long-term changes in the environment and marine biota, as well as bolster quantitative research in the future, to better understand the environmental impacts of climate change on the Beaufort marine ecosystems.

RESUME

Brewster, J. D., Neumann, D., Ostertag, S. K., and Loseto, L. L. 2016. Les connaissances écologiques traditionnelles (CET) à Shingle Point, Yukon : observations sur les changements environnementaux et les populations de poissons. Rapp. tech. can. sci. halieut. aquat. 3174: v + 23 p.

La compréhension des changements environnementaux et l'établissement de données de base relatives à la mer de Beaufort sont une étape cruciale du soutien des populations de poissons et des habitats du poisson face au changement climatique dans l'Arctique. Shingle Point, au Yukon, est une communauté de pêche et de chasse traditionnelle et moderne pour les peuples autochtones de l'Arctique de l'Ouest et fait partie d'une aire marine protégée (AMP) de la région désignée des Inuvialuit (RDI). L'intégration des CET est importante si l'on veut comprendre les changements apportés à cet habitat côtier. Au cours de l'été 2015, les pêcheurs de Shingle Point et leur famille ont participé à des entrevues portant sur les CET. Les entrevues ont permis de recueillir des données d'observation sur : 1) les changements dans les populations de poissons, 2) les changements environnementaux, 3) les préoccupations, 4) les raisons de retourner à Shingle Point. Les résultats obtenus lors des entrevues sur les CET révèlent que l'on observe des changements environnementaux et des changements dans les populations de poissons côtiers depuis des décennies. Il est possible d'avoir recours aux CET sous forme d'entrevues et de questionnaires sans orientation précise pour documenter et comprendre les changements environnementaux et les changements du biote marin à long terme ainsi que pour améliorer la recherche quantitative dans les prochaines années et mieux comprendre les répercussions des changements climatiques sur les écosystèmes de la mer de Beaufort.

INTRODUCTION

Located along the coastline of the Yukon Territory in the Canadian Arctic, is a long gravel spit, known as Shingle Point (Figure 1). Shingle Point has long been known as a traditional and modern day fishing and hunting camp for Western Arctic indigenous people. The Inuvialuit and Gwitch'in peoples are the prevalent indigenous groups in the Western Arctic region. Families from the Northwest Territories, Yukon, and northeast Alaska have been returning to Shingle Point for generations. In particular, families from the nearby communities of Aklavik and Inuvik travel to Shingle Point annually for subsistence fishing, whaling and berry picking in the summer and fall, and caribou hunting in the winter. The consistent use of the area by local peoples and the traditional ecological knowledge (TEK) that has been passed on along many generations is of great value for understanding change in the environment over time.

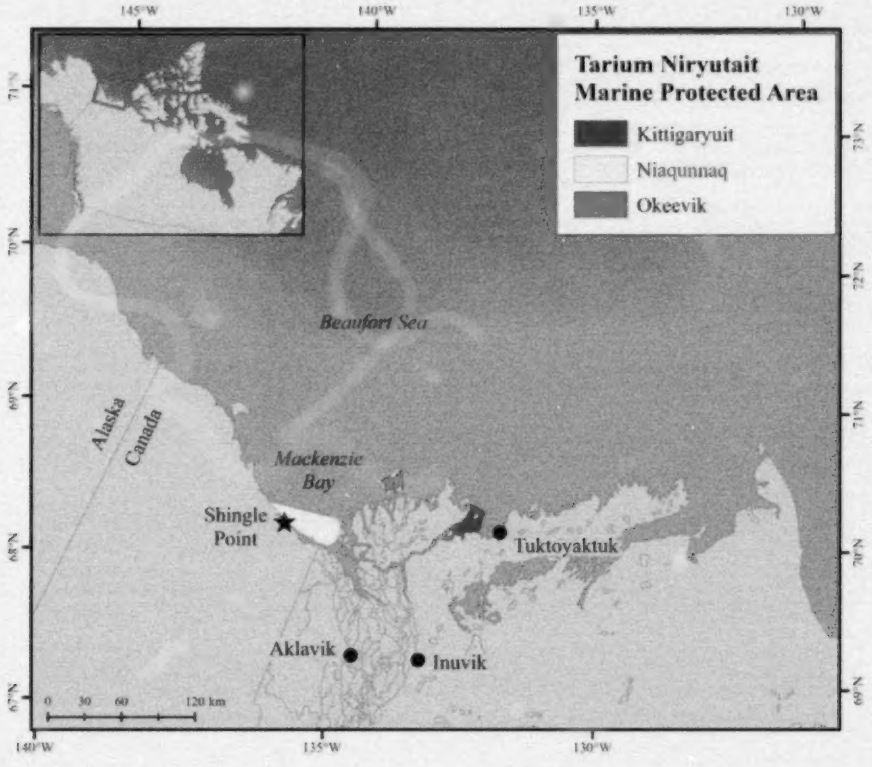


Figure 1. Map of the Tarium Niryutait Marine Protected Area (TNMPA) and place names used in this report.

Traditional and current use of Shingle Point for subsistence suggests that this location is a reliable and abundant source of wildlife. Shingle Point is a long narrow coastal spit embedded in estuarine habitat. The mixing of Beaufort Sea marine waters and freshwater from the Mackenzie River creates an intermediate environment for freshwater, anadromous, and marine fish species (Carmack and Macdonald 2002). Many of the anadromous fishes, for example, Arctic Cisco (*Coregonus autumnalis*) and Dolly Varden Char (*Salvelinus malma*) are of great cultural importance to the Inuvialuit and Gwich'in. These fishes are also important prey for many of the marine mammals that utilize the area. The months of June, July and August, are the most active time for a number of fish species as they forage in the nutrient rich brackish and marine waters before returning to their respective over-wintering habitats (Reist and Bond 1988; Reist and Sawatzky 2010).

Climate change and increased pressure for industrial development and marine transport continue to impact Arctic marine ecosystems (Cobb et al. 2008; Stroeve et al. 2012). Currently, we still do not fully understand the distribution range for many fish species located in the Beaufort Sea (Reist et al. 2002; Reist et al. 2006). The determination of this type of baseline information is a crucial step in managing and thereby sustaining fish populations and habitats, and the ability to identify the effects of environmental and industrial stressors. For these reasons, understanding the ecosystem and fish use at Shingle Point is important to understanding and sustaining these valuable resources (Usher 2002; Cobb et al. 2008; Loseto et al. 2009).

Fisheries and Oceans Canada (DFO) has established a number of fish monitoring programs from Shingle Point. For example, the Tarium Niryuitait Marine Protected Area (TNMPA) was established in 2010, in effort to protect beluga and their supporting habitat and prey (DFO and FJMC 2013a, 2013b). Three regions of the Mackenzie Estuary make up the TNMPA: Niaqunnaq, Okeevik and Kittigaryuit (Figure 1). Shingle Point is located within the Niaqunnaq region (Fast et al. 2001; Fast et al. 2005, Harwood et al. 2014). As part of the management and monitoring of the TNMPA, fish monitoring is incorporated in the reporting of the conservation objectives for the TNMPA (DFO 2010, DFO 2012). Additionally, the Arctic Coastal Ecosystem Study (ACES) was established at Shingle Point to monitor the fish populations in the nearshore estuarine environment, where in total 16 species of fish (listed in Table 1) have been consistently

caught each year (2010-2015). Under the ACES program, researchers and Aklavik Hunters and Trappers Committee (HTC) monitors have been collecting fish samples from Shingle Point since 2010 to present. This is also the case for the ACES and the Dolly Varden Char Harvest Monitoring programs at the Shingle Point location. These monitoring programs are instrumental for reporting under the TNMPA and to help fill a number of knowledge gaps that currently exist at Shingle Point and for a number of Beaufort Sea fishes.

Often long-term data in Arctic ecosystems is difficult to collect, and is limited by season and climatic conditions, but because Shingle Point is regularly visited year round, TEK studies can be conducted in order to understand and monitor the health of the marine ecosystem. The on-going monitoring of fishes at Shingle Point prompts a unique opportunity to merge the generations of traditional observational data with the quantitative biological data collected by researchers. During the 2015 field season TEK questionnaires and interviews were conducted at Shingle Point. In this study TEK is defined as the collection of indigenous knowledge, techniques, and beliefs of how to live on the land; this knowledge is passed on through generations (Johannes 1989). Therefore, participants included elders returning to Shingle Point, as well as younger participants whose knowledge stem from stories being passed down. This study was requested and is supported by the Aklavik HTC and the Fisheries Joint Management Committee (FJMC). The coupling of TEK alongside biological data will help to strengthen the current ecosystem-monitoring programs by focusing the research on the subjects of concern and to better understand the long-term changes in the coastal environment and fish populations.

MATERIALS AND METHODS

STUDY AREA

Shingle Point is a 7 km gravel spit located on the Yukon coastline (68°57'N, 137°13'W), west of the Northwest Territories border (Figure 1). The spit is connected to tundra on one end and is surrounded by the Mackenzie Bay on the remaining three sides. The north side is exposed to the waters of greater salinity (i.e., Beaufort Sea marine waters). The side opposite of the ocean, referred to by locals as the "bay side", is less saline, and is known as brackish water. Brackish water is a mixture of marine water and freshwater. The origin of freshwater at this location is due to the outflow of the Mackenzie River (Craig 1984; Carmack and Macdonald 2002). Subsistence

fishing takes place on both sides of the spit. Three camps make up the fishing community at Shingle Point (Figure 2). The "Down the Hill Camp" is located where the spit connects with the tundra (Figure 2). This camp is the most sheltered from weather and storms coming in from the Beaufort Sea. The "Middle Camp" is located in the center of the gravel spit, and the "Point Camp" is at the far end, at the opening of the bay, and is exposed to the Beaufort Sea on three sides (Figure 2).

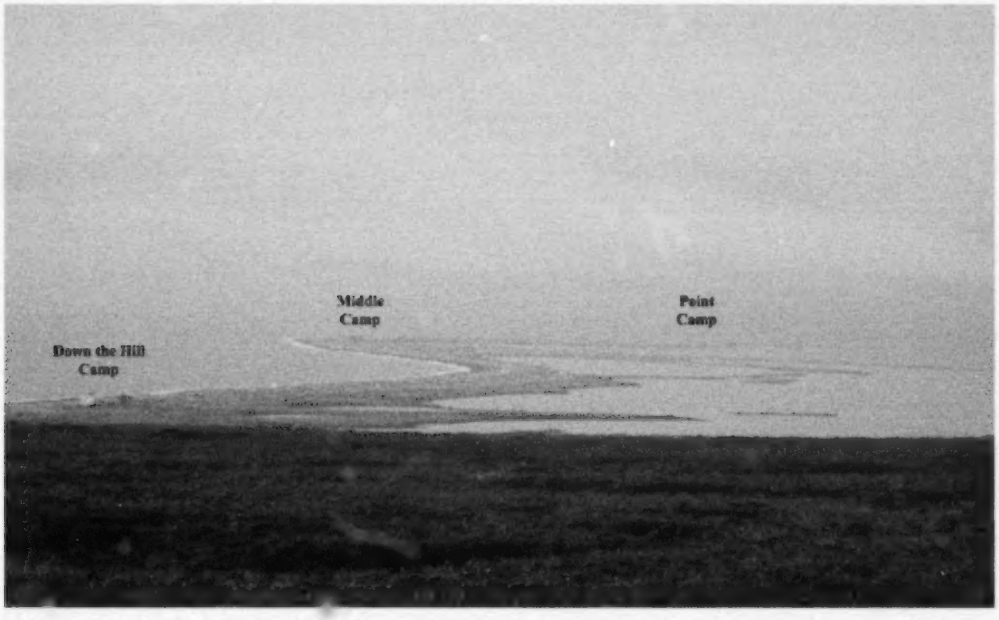


Figure 2. Photo of the three Shingle Point, YT camps. The Down the Hill camp is connected to the tundra (i.e., mainland) and the Middle and Point camps are located further into the Mackenzie Bay. (Photo courtesy of Dana Neumann).

MONITORING PROGRAM FISH COLLECTION

As part of the existing DFO monitoring programs that have been ongoing at Shingle Point since 2010, inventories of fish species captured at various sample sites have been collected. These fishes have been collected using various methods over the years, and were collected collaboratively between researchers and the local harvesters (i.e., Aklavik HTC monitors, harvesters from each of the three camps). A total of 16 fish species have been consistently caught every year since the monitoring programs have been operating. This study focuses on those fish species most commonly captured in order to established baseline distributions from the monitoring program with the TEK. Table 1 provides a list of those common species, familiar to the local harvesters, with traditional names and a brief description of their ecology (Table 1).

TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK) QUESTIONNAIRE

A questionnaire was drafted and reviewed by the Aklavik HTC. The HTC provided feedback and requested a local summer student be hired to assist with the interviews. The questionnaire then went through two ethics screening processes to ensure that it, and the interview process, followed the guidelines under the University of Manitoba Fort Garry Campus Research Ethics Board. The Aklavik HTC and the Ethics committee approved the final draft of the questionnaire in June of 2015 (Appendix 1). Interviews were conducted using the questionnaire questions. Questions included topics on the health and abundance of the 16 common fish species captured at Shingle Point, observational changes in the environment (i.e., land, temperature, water), and other concerns. The results were categorized into four sections: Fish Population Changes, Environmental Changes, Concerns and Why People Return.

TEK interviews were then conducted during and between fish sampling in July 2015 by a field team of DFO, and HTC youth (Appendix 2). In order to encourage collaboration and support, a handout was distributed to the local harvesters and their families prior to the interview. The handout included pictures of the 16 common fish species consistently harvested (Appendix 3) with an extra blank column (information box) for the individual to document any observed changes and interesting observations during their time at Shingle Point.

The Aklavik HTC hired two youth from Aklavik to assist with the TEK interviews. This allowed for a more comfortable and relaxed interview with community members. Interviews were recorded both on a voice recorder and written on each questionnaire. Participants could request to remain anonymous, stop the interview at any time or chose not to be voice recorded. The prepared questions were formatted to be specific and open-ended, to allow for participants to share experiences, observations, opinions and concerns (Huntington, 1998). Guardians of participants under the age of 18 signed a consent form. The HTC summer students were asked to sign forms prior to the interviews to protect the anonymity and privacy of participants. All the interview recordings and results are securely held at the DFO Freshwater Institute, Winnipeg, MB. The qualitative software "NVIVO" was used to analyze word counts and word associations, thereby identifying common trends within each interview.

Table 1. Fish species consistently caught at Shingle Point from 2010-2013. Fishes that migrate from freshwater to marine will stop in the coastal/estuarine environment to adjust to the change in environment. The habitat column uses arrows (→) to indicate fishes migrating to and from different habitats, and function describes why we suspect migration to occur.

Common and Scientific Name	Traditional Name	Habitat	Function	Feeding Ecology	Diet
Arctic Cisco (*Coregonus autumnalis*)	Herring	Freshwater →	- Spawning - Overwinter	- Open water feeding - Bottom feeding	Shellfish, insects, small fishes, worms
		Marine	- Coastal movement - foraging, growth and maturation (summer)		
Arctic Flounder (*Liopsetta glacialis*)	Flat fish	Marine	- Non-migratory, but enters coastal waters to feed	- Bottom feeding	Small fishes, shellfish
Broad Whitefish (*Coregonus nasus*)	Whitefish	Freshwater →	- Moves upstream to spawn	- Open water feeding (young) - Bottom feeding (adult)	Zooplankton (young), shellfish (adults)
		Coastal/Estuarine (freshened waters)	- Foraging, growth and maturation (summer)		
Burbot (*Lota lota*)	Losh	Freshwater	- Non-migratory, but enters coastal waters to feed	- Open water feeding - Possible Benthic feeding	Insect larvae (young), shellfish (young), fishes (adults)

Common and Scientific Name	Traditional Name	Habitat	Function	Feeding Ecology	Diet
Dolly Varden Char (*Salvelinus malma*)	Char	Freshwater →	- Overwintering, growth (young), spawning (adults)	- Open water feeding - Bottom feeding	Insects, shellfish, fish eggs (young), fishes (adults)
		Marine	- Foraging, growth and maturation (summer)		
Four-horn Sculpin (*Myoxocephalus quadricornis*)	Devil Fish	Marine	- Non-migratory, but enters coastal waters to feed	- Bottom feeding	Shellfish, fishes
Inconnu (*Stenodus leucichthys*)	Conie	Freshwater →	- Spawning - Overwintering	- Open water feeding - Bottom feeding	Insect larvae (young), planktonic shellfish (young), small fishes (adults)
		Marine	- Foraging, growth (summer)		
Lake Whitefish (*Coregonus clupeaformis*)	Crooked Back	Freshwater →	- Spawn - Overwinter	- Bottom feeding	Insect larvae, shellfish, fishes, fish eggs (including their own)
		Coastal/Estuarine	- Foraging, growth and maturation (summer)		
Longnose Sucker (*Catostomus catostomus*)		Freshwater	- Non-migratory, but enters coastal waters to feed	- Bottom feeding	Shellfish

Common and Scientific Name	Traditional Name	Habitat	Function	Feeding Ecology	Diet
Least Cisco (*Coregonus sardinella*)		Freshwater →	- Spawn - Overwinter	- Open water feeding	Planktonic shellfish, plants
		Marine	- Foraging, growth and maturation (summer)		
Northern Pike (*Esox lucius*)	Pike	Freshwater →	- Spawn - Foraging	- Open water feeding	Shellfish (young), crayfish (adults), frogs (adults), fishes including cannibalism (adults)
		Coastal/Estuarine	- Foraging, growth, maturation (summer) - Reduce parasitism (summer)		
Saffron Cod (*Elegimus gracilis*)	Tom Cod	Marine →	- Foraging, growth, maturation	- Bottom feeding	Opportunistic (e.g., fish, shellfish)
		Coastal/Estuarine	- Spawn - Overwinter		
Starry Flounder (*Platichthys stellatus*)	Flat Fish	Marine	- Non-migratory, but enters coastal waters to feed - May move far offshore in winter	- Bottom feeding	Shellfish, worms, brittle stars, small fishes

Common and Scientific Name	Traditional Name	Habitat	Function	Feeding Ecology	Diet
Pacific Herring (*Clupea pallasii*)		Marine →	- Migratory behavior is not fully understood - Foraging, growth, maturation	- Open water feeding	Shellfish larvae (young), shellfish (adults), small fishes (adults)
		Coastal/Estuarine	- Spawning		
Rainbow Smelt (*Osmerus mordax*)	Stink Fish	Freshwater →	- Spawning	- Open water feeding	Shellfish, copepods, small fishes
		Marine	- Foraging, growth, maturation		
Round Whitefish (*Prosopium cylindraceum*)	Lake Fish	Freshwater →	- Spawning	- Bottom feeding	Shellfish, fishes, fish eggs
		Coastal/Estuarine	- Foraging, growth, maturation		

RESULTS

In total, there were 15 participants (Table 2). Only 12 interviews were conducted, since some participants decided to interview collectively with their respective families (Table 2). Results from the TEK interviews indicated that Shingle Point community members have been observing changes at Shingle Point since the 1960s and 1980s.Participant responses were grouped into four categories: fish population change, increase in air temperature, increase in water temperature and concern (Figure 3). Overall, most participants were concerned with the observed environmental change (73%; Figure 3). The most frequent observation was related to potentially higher water temperature at Shingle Point, this lead to concerns on how this would impact fish populations, and their supporting habitat. (Figure 3).

Table 2. List of participants and their home community and camp location for the the Shingle Point Traditional Ecological Knowledge (TEK) interview conducted in July 2015. Also includes information about how the interview was conducted (e.g., family, individual).

Interview Number	Name OR Identification Number	Home Community	Camp Location	Information
1	Jerry Arey Verna Arey Colton Arey	Aklavik	Down the hill	Family
2	Thomas Gordon	Aklavik	Down the hill	Individual
3	Melinda Cockney Topsy Cockney	Inuvik	No camp; spends time at the Point camp	Mother and Daughter
4	Annie B. Gruben	Aklavik	Point	Individual
5	0001	Anonymous	Point	Individual
6	Gerry Kisoun	Inuvik	Visits friends and family at Down the hill camp	Individual; originally from the Mackenzie Delta
7	0002	Aklavik	Anonymous	Individual; no recording
8	0003	Aklavik	Down the hill	Individual
9	0004	Aklavik	Down the hill	Individual
10	Jordan McLeod	Aklavik	Middle	Individual
11	Tom McLeod	Aklavik, then Inuvik	Point	Individual
12	Denise Arey	Aklavik	Middle Camp	Individual

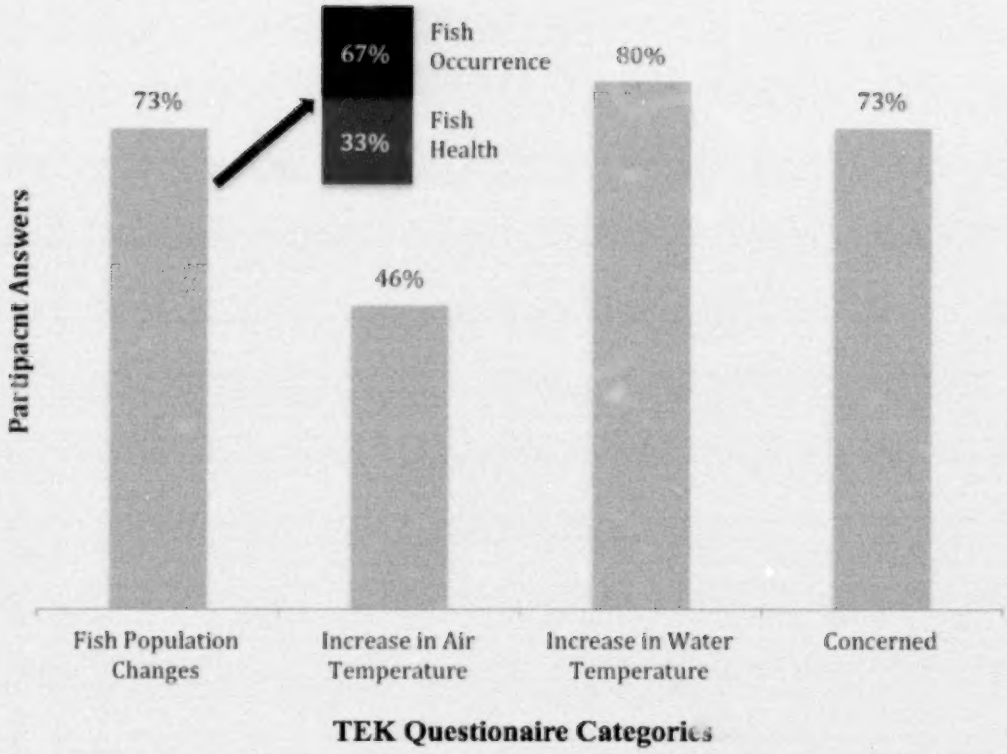


Figure 3. Results (%) of participant answers to the Traditional Ecological Knowledge (TEK) questionnaire from Shingle Point, YT for the 2015 study. The fish population change category was further divided into two sub-categories: fish occurrence and fish health.

CHANGE IN FISH POPULATIONS

The majority of questions during the interview were related to observed changes in fish occurrence over the years. Of the 15 participants who took part in the TEK questionnaire, 11 (73%) stated that they have noticed changes in fish occurrence (67%) and the general health of fish (33%) in the area (Figure 3). The greatest change was associated to the time of arrival of Dolly Varden Char, where observations indicate they are migrating earlier (i.e., in July) to the Mackenzie Bay; and at the same time as Arctic Cisco. It was speculated that these species prefer cooler waters, and that the increase in water temperature is affecting the time of arrival. Fish population changes were addressed as another concern by participants, where freshwater species

were most associated with the fish occurrence sub-category (Figure 3). Six of the participants noted an observed increase in freshwater species. Specifically, individuals stated an increase in Inconnu (*Stenodus leucichthys)*, fluctuations in Saffron Cod (*Eleginus gracilis)* abundance, and a decrease in flounders and Fourhorn Sculpin (*Myoxocephalus quadricornis)*. Arctic Cisco was the species most associated with the fish health category, where 5 participants indicated an increase in the observation of worms present in the muscle tissue.

The highest word count (n) from the interview results indicate that observational changes exist in both occurrence (n=47) and abundance (n=22) of fish. On topics such as, being an important food source, changes in migration and occurrence, abundance changes, and health, Arctic Cisco was mentioned the most (n=53), followed by Dolly Varden Char (n=34).

The following quotes are meant to show some common trends in the TEK interviews. An elder from Aklavik, NT, Annie B, uses the walls of her Shingle Point house to document important events. In her interview she pointed to September 1, 1995 and said:

> *" If you are here early sometimes belugas came right in to the bay. They are always on the deep side (ocean side), but in September then come right into the bay. But that was a long time ago, last time was 1995 September 1st." ~Annie B*

> *" The timing of fish, char has changed since I started coming to Shingle. They use to come in early July with herring over the years. Last couple years char is later in the season maybe early August late July. Herring when the run is on is the main fish we catch, then conie. We are lucky to get char and whitefish." ~Anonymous*

> *"We're not getting as much herring in the mouth east channel around Tuk. This is where the fish are coming from when they come to Shingle Point". ~Gerry Kisoun*

ENVIRONMENTAL CHANGES

The TEK questionnaires indicated that air and water temperatures have increased at Shingle Point over the years (47% and 80%, respectively; Figure 3). Shingle Point has been a traditional hunting and fishing ground for subsistence for decades. Now community members like Jerry Arey, are saying that it is becoming harder to predict the weather, that this is affecting their

hunting season, and that the timing and abundance of caribou herds is also changing. There are more storms in the area and this is affecting when people are able to travel to and from Shingle Point. Other interviews stated that people will not travel to Shingle Point with a warm northwest wind, and that it is becoming harder to tell when it is safe to travel. Environmental changes observed went beyond the marine environment. Common topics included: the degradation and slumping of the hills into the estuary and ocean, the loss of sea ice, and decrease of snow in the hills. Participants stated that there are less caribou, and that there used to be jellyfish on the ocean side, and now there are none.

> *"All kinds of changes too much, you can't keep track of everything. Elders use to look at the sky, look at the water, and they look at the clouds. How all that tells the weather I don't know, but that's how they knew when a big wind was coming, when its going to change the weather. I don't know how they could tell that, but that is how our elders were. Every year it seems to get more hotter, the hills are more different now, all the hills are sliding into the water. Every year is changing." ~Annie B*

> *"A lot of changes over the years. I have been here for 20 years around and I have been seeing so much change in such a little amount of time. I always use to see snow, and now not seeing snow is very unusual. First not seeing ice was unusual now not seeing snow is unusual. Things are changing more rapidly, not slowly, faster and faster." ~Anonymous*

> *"The water temperature is changing. The bay and ocean side had ice and was cold when grandparents were here. Now water is warm, lots of rain and thunder and different winds" ~Anonymous*

> *"For hunting there are less caribou, they follow the lichen. Because there is no lichen they follow their food." ~Denise Arey*

CONCERNS

From the 15 participates 11 (73%) stated that they were concerned with the observed fish population, and environmental changes (Figure 3). A number of the participants stated that Arctic Cisco have more worms in the muscle tissue. They are concerned with the health of this

species, and if it is safe to eat when prepared as dry fish. The changes in the environment are evident to the people that frequent Shingle Point; concerns are highly associated with how the physical environmental changes are going to affect the biota. Some examples include:

> *"Why is the ocean moving further and further from my house. When I was eight the ocean was much closer." ~Jerry Arey*

> *"The permafrost melting must be causing the slumping and mud slides to increase. What are the implications of this? The mud slights have increased from here to Hershall." ~Melinda Gillis*

> *"The icebergs have not been here for years. They are part of the habitat for fish. What will happen now?" -Eugene Pascal*

REASONS TO RETURN TO SHINGLE POINT

Shingle Point is socially and culturally an important destination for the returning families. Interviewed participants shared common views on what Shingle Point is to themselves and their families. Some of the responses as to why they continue to return to the area include: a vacation away from technology, hunting for caribou (August, over winter), berry picking, whaling, fishing, and the annual Shingle Point games. Colton Arey is one of the many youth that return to Shingle Point with his family for fun, and to learn the traditional practices of capturing and preparing fish for food.

> *"This is Life" ~Denise Arey*

SUMMARY

The effects of a changing climate are impacting the Arctic marine environment but the extent and long-term impact are generally unknown (e.g., Arrigo et al. 2008; Lavioe and Denman 2010; Barber et al. 2012). Often the inability to understand change is due to a lack of baseline information and a good understanding of the previous state of the marine environment. Monitoring programs are very useful for identifying change and providing some insight as to the reason for change. The use of TEK and local observations are a useful tool to compliment

quantitative monitoring programs to detect long-term change or provide advice to program development and focus monitoring objectives and indicators.

The TEK questionnaires and interviews conducted at Shingle Point in July 2015 was meant to record the TEK and long-term observations of returning Shingle Point families and individuals to discuss fish populations, the environment, and their personal experiences. The results of the TEK questions could be categorized into four sections: observed fish population changes, increases in air and water temperature (environmental changes), and concerns. The majority of participants stated that they did notice changes in the fish population, where fish occurrence, in particular changes in the timing of the Dolly Varden Char migration, and fish health (i.e., worms in Arctic Cisco). Arctic Cisco, Dolly Varden Char, Broad Whitefish (*Coregonus nasus*), and Inconnu are important subsistence species for the Inuvialuit and Gwich'in people, causing the majority of interviews to focus on these species.

Increases in air and water temperature observed by the majority of participants suggest that environmental changes have been affecting this area for generations. With overwhelming evidence of a warming Arctic, sea ice extent has decreased affecting the marine ecosystem (e.g., Arrigo et al. 2008; Serreze et al. 2008; Barber et al. 2012), and the Beaufort indigenous peoples who rely on the species for subsistence (Usher 2002). Many of the participants in this study mentioned their concerns about the changes they have observed over the years (e.g., increased mudslides, decrease in ice, change in fish occurrence). Further to this, they all acknowledged the explicit link between the state of the environment (e.g., habitat, water quality) and the marine biota. There is great concern that changes that have been observed will affect the health of the fish populations in the future.

The collaboration between researchers and the Inuvialuit and Gwitch' in during the annual DFO fish monitoring programs at Shingle Point has resulted in an increased understanding of the anadromous, freshwater and marine fishes in nearshore estuaries (e.g., Loseto et al. 2009; Gallagher et al. 2013; Loewen et al. 2015; Brewster et al. in review). Results from this TEK questionnaire indicated that observational knowledge of TEK holders at Shingle Point contains important long-term monitoring data that can help inform the development of monitoring objectives and indicators, and the assessment of these indicators. Thus, the collection and

integration of TEK alongside scientific data should continue to be implemented in monitoring programs of Beaufort coastal habitats. The utilization of TEK in the form of specific and open-ended interviews/questionnaires can be used to document and understand long-term changes in the environment and marine biota, as well as bolster quantitative research in the future, to better understand the environmental impacts of climate change on the Beaufort marine ecosystems.

ACKNOWLEDGMENTS

The participation and support from families at Shingle Point allowed for the successful collection of TEK and completion of this report. We want to thank youth monitors Cecilia McLeod and Desiree Arey, and DFO employee Kate Snow for assisting in conducting interviews. Thank you to Tracey Loewen and Colin Gallagher who provided the images of the fish species found in Appendix 3, and Jim Reist for providing expertise to populate Table 1. Also thank you to Joclyn Paulic, Vic Gillman, Michelle Grueben and the Aklavik Hunters and Trappers Committee (HTC) for reviewing and providing feedback that improved the report. The Aklavik HTC, Fisheries Joint Management Committee, and Fisheries and Oceans Canada financially supported this report.

REFERENCES

Arrigo, K.R., Dijken, G.V., and Pabi, S. 2008. Impact of a shrinking Arctic ice cover on marine primary production. Geophys. Res. Lett. 35: 1–6.

Barber, D.G., Asplin, M.G., Papakyriakou, T.N., Miller, L., Else, B.G.T., Iacozza, J., Mundy, C.J., Gosslin, M., Asselin, N.C., Ferguson, S., Lukovich, J.V., Stern, G. A., Gaden, A., Pućko, M., Geilfus, N.X., and Wang, F. 2012. Consequences of change and variability in sea ice on marine ecosystem and biogeochemical processes during the 2007-2008 Canadian International Polar Year program. Clim. Chang. 115: 135–159.

Brewster, J.D., Giraldo, C., Swanson, H., Walkusz, W., Loewen, T., Reist, J.D., Stern, G.A., and Losteo, L.L. 2016. Ecological niche of coastal Beaufort Sea fishes defined by biotracers: Recommendations for a marine protected area monitoring program. Mar.Ecol.Prog. Ser.

Carmack, E.C., and Macdonald, R.W. 2002. Oceanography of the Canadian shelf of the Beaufort Sea: A setting for marine life. Arctic. 55: 29–45.

Cobb, D., Fast, H., Papst, M.H., Rosenberg, D., Rutherford, R., and Sareault, J.E. (Editors). 2008. Beaufort Sea Large Ocean Management Area: Ecosystem Overview and Assessment Report. Can. Tech. Rep. Fish. Aquat. Sci. 2780: ix + 188 p.

Craig, P.C. 1984. Fish use of coastal waters of the Alaska Beaufort Sea: a review. Trans. Am. Fish. Soc. 113: 265–282.

DFO and FJMC (Fisheries and Oceans Canada and Fisheries Joint Management Committee). 2013a. Tarium Niryutait Marine Protected Area: Management Plan. DFO. Winnipeg, MB. Unpublished report.

DFO and FJMC (Fisheries and Oceans Canada and Fisheries Joint Management Committee). 2013b. Tarium Niryutait Marine Protected Area: Monitoring Plan. DFO. Winnipeg, MB. Unpublished report.

Fast, H., Mathias, J., and Banias, O. 2001. Directions toward marine conservation in Canada's Western Arctic. J. Ocean Coast. Manag. 44: 183-205.

Fast, H., Chiperzak, D., Cott, K., and Elliott, G. 2005. Integrated management planning in Canada's Western Arctic: an adaptive approach. *In* Breaking Ice. Renewable Resource and Ocean Management in the Canadian North. Edited by F. Birkes, R. Huebert, H. Fast, M. Manseau, and A. Diduck, A. University of Calgary Press. 396 p.

Gallagher, C.P., Howland, K.L., Harris, L.N., Bajno, R., Sandstrom, S., Loewen, T., and Reist, J. 2013. Dolly Varden (*Salvelinus malma malma*) from the Big Fish River: abundance estimates, effective population size, biological characteristics, and contribution to the coastal mixed-stock fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/059. v + 46 p.

Harwood, L.A., Iacozza, J., Auld, J.C., Norton, P., and Loseto, L. 2014. Belugas in the Mackenzie River estuary, NT, Canada: Habitat use and hot spots in the Tarium Niryutait Marine Protected Area. Ocean. Coast. Manag. 100: 128–138.

Huntington, H. P. 1998. Observations on the Utility of the Semi-Directive Interview for Documenting Traditional Ecological Knowledge. Arctic. 51: 237–242.

Johannes, R.E. (Ed.). 1989. Traditional Ecological Knowledge: A collection of Essays. IUCN, Gland, Switzerland and Cambridge, UK. 77 p.

Lavoie, D., Denman, K.L., and Macdonald, R.W. 2010. Effects of future climate change on primary productivity and export fluxes in the Beaufort Sea. J. Geophys. Res. Ocean. 115: 1–15.

Loseto, L.L., Stern, G. A., Connelly, T.L., Deibel, D., Gemmill, B., Prokopowicz, A., Fortier, L., and Ferguson, S.H. 2009. Summer diet of beluga whales inferred by fatty acid analysis of the eastern Beaufort Sea food web. J. Exp. Mar. Bio. Ecol. 374: 12–18.

Loewen, T.N., Reist, J.D., Yang, P., Koleszar, A., Babaluk, J.A., Mochnacz, N., and Halden, N.M. 2015. Discrimination of northern form Dolly Varden Char (Salvelinus malma malma) stocks of the North Slope, Yukon and Northwest Territories, Canada via otolith trace elements and $^{87}Sr/^{86}Sr$ isotopes. Fish. Res. 170: 116–124.

Reist, J.D., and Bond, W.A. 1988. Life history characteristics of migratory coregonids of the lower Mackenzie River, Northwest Territories, Canada. Finnish. Fish. Res. 9: 133–144.

Reist, J.D., Low, G., Johnson, J.D., and McDowell, D. 2002. Range Extension of Bull Trout, Salvelinus confluentus, to the Central Northwest Territories, with Notes on Identification and Distribution of Dolly Varden, Salvelinus malma, in the Western Canadian Arctic. Arctic. 55: 70-76.

Reist, J.D., and Sawatzky, C.D. 2010. Diversity and Distribution of Chars, Genus Salvelinus, in Northwestern North America in the Context of Northern Dolly Varden (*Salvelinus malma malma* (Walbaum 1792)). DFO. Can. Sci. Advis. Sec. Res. Doc. 2010/014. vi + 18 p.

Reist, J.D., Wrona, F.J., Prowse, T.D., Power, M., Dempson, J.B., King, J.R., and Beamish, R.J. 2006. An overview of effects of climate change on selected arctic freshwater and anadromous fishes. Ambio. 35: 381-387.

Serreze, M.C., Barrett, A.P., Stroeve, J.C., Kindig, D.N., and Holland, M.M. 2008. The emergence of surface-based Arctic amplification. Cryosph. Discuss. 2: 601–622.

Stroeve, J.C., Serreze, M.C., Holland, M.M., Kay, J.E., Malanik, J., and Barrett, A.P. 2012. The Arctic's rapidly shrinking sea ice cover: A research synthesis. Clim. Chang. 110: 1005–1027.

Usher, P.J. 2002. Inuvialuit use of the Beaufort Sea and its resources, 1960-2000. Arctic. 55: 18–28.

APPENDIX 1. Shingle Point, YT fish population questionnaire.

Name:_____

Anonymity? Yes No

Hometown:_____

1) How many years have you been coming out to Shingle Point? How long has your family?

2) Were there other places that you used to set nets in the past? Has the timing of fish changed since you started coming to Shingle?

3) Have you noticed a change in the weather and water temperature over the years? Can you describe these changes?

4) Did you or your family always come to Shingle Point for fish or were there other reasons to come to Shingle Point in the past (i.e. beluga)?

5) What type of nets do you prefer to fish with, where do you set them (ocean side, or lagoon), and is this species specific?

6) Using the fish guide attached, please provide your observations about changes in the presence and abundance of fish species at Shingle Point.

   a) more abundant b) less abundant c) no change in abundance

7) Which fish do you usually catch?

8) Have you noticed any changes in health of this/these fish over time? Describe the changes that you have noticed for each species that you usually catch:

   Species:_____

   a) More fat b) Less fat c) No change

   b) Change in colour:_____
   c) Change in muscle texture:_____
   d) Other:_____

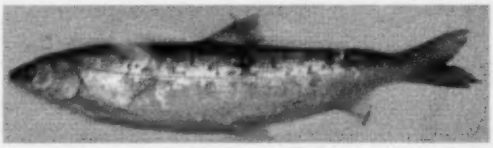
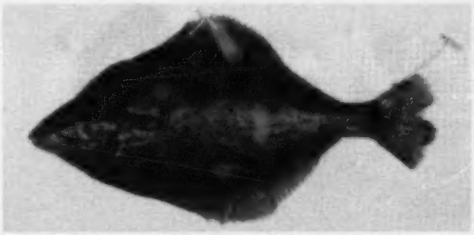
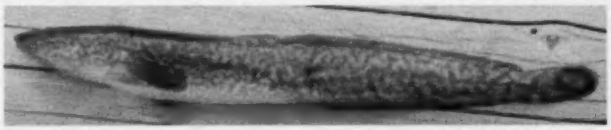
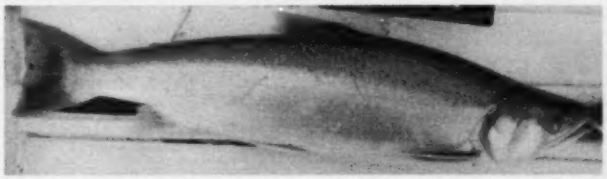
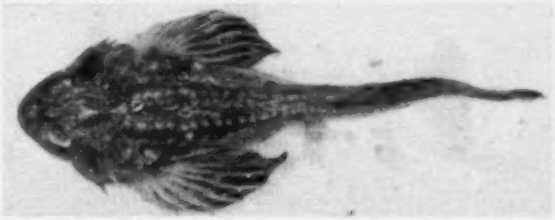
9) How are youth in your family involved in fishing at Shingle point?

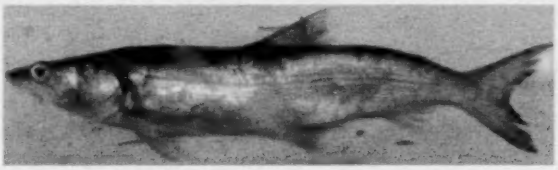
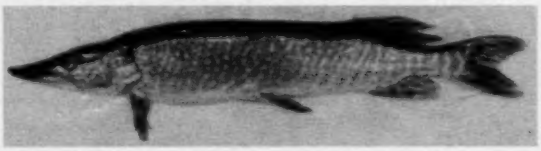
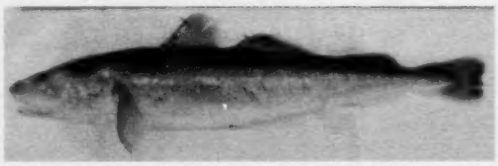
10) Do you have concerns about the fish at Shingle Point, or feedback that this questionnaire did not touch on?

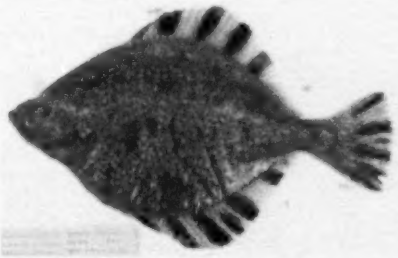
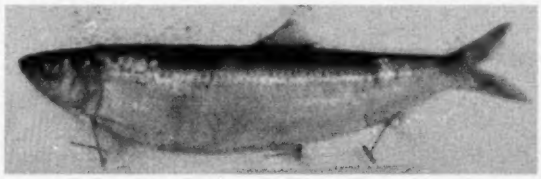
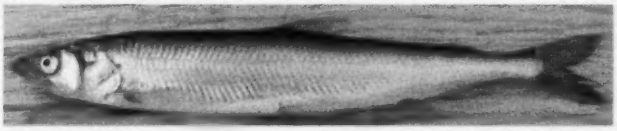
APPENDIX 2. Field team for the 2015 Shingle Point Traditional Ecological Knowledge (TEK) interviews.

Name	Position	Organization
Dana Neumann	Lab and Field Technician	Fisheries and Oceans Canada, Winnipeg, MB
Jasmine Brewster	Graduate Student	University of Manitoba and Fisheries and Oceans Canada, Winnipeg, MB
Kate Snow	Technician	Fisheries and Oceans Canada, Inuvik, NT
Cecilia McLeod	Youth	Aklavik Community Member
Desiree Arey	Youth	Aklavik Community Member

APPENDIX 3. Fish species catalogue for Shingle Point, YT, including common and latin names and pictures for identification.

Species Common and Latin Name	Picture
Arctic Cisco ***(Coregonus autumnalis)***	
Arctic Flounder ***(Liopsetta glacialis)***	
Broad Whitefish ***(Coregonus nasus)***	
Burbot ***(Lota lota)***	
Dolly Varden ***(Salvelinus malma)***	
Four Horn Sculpin ***(Myoxocephalus quadricornis)***	

Species Common and Latin Name	Picture
Inconnu ***(Stenodus leucichthys)***	
Lake Whitefish ***(Coregonus clupeaformis)***	
Longnose Sucker ***(Catostomus catostomus)***	
Least Cisco ***(Coregonus sardinella)***	
Northern Pike ***(Esox lucius)***	
Saffron Cod ***(Eleginus gracilis)***	

Species Common and Latin Name	Picture
Starry Flounder ***(Platichthys stellatus)***	
Pacific Herring ***(Clupea pallasii)***	
Rainbow Smelt ***(Osmerus mordax)***	
Round Whitefish ***(Prosopium cylindraceum)***